Comment on "Magnus force and acoustic Stewart-Tolman effect in type-II superconductors, by Fil *et al.*"

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Abstract

Fil *et al.* has proposed an interesting experimental method to investigate vortex dynamics. Some preliminary results have been obtained. In this comment I discuss a few missing but strongly related theoretical models and experiments on Hall anomaly and Magnus force. I conclude that those missing literature can enhance the value of novel experimental method proposed in the commented 2006 Europhysics Letters by Fil *et al.*.

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In their letter Fil et al [1] presented a novel experimental method to check various dynamical elements in the fundamental equation of vortex. It is likely that new information on vortex dynamics can be obtained, which may help to resolve outstanding puzzles. Nevertheless, a few key facts were presented wrong, which will make the interpretation of their data difficult, if not introducing additional confusing. Here I wish to point out such mistakes.

1) A well-known microscopic theory of effective Magnus force on a single moving vortex predicts its magnitude is greatly reduced by the relaxation time due to impurity at length scale smaller than the coherence length, which does not agree with the expectation of classical limit. This theory was summarized in Ref. [2] of Fil et al..

However, it was pointed out that the use of relaxation time approximation is wrong in this context [2]. In additional, a competing microscopic theory has reached the opposite conclusion that the magnitude of the Magnus force should be what expected in the classical limit in the light of two fluid type model [3], and both the Magnus force and the vortex friction have been derived without the relaxation time approximation [3, 4], further extended by others [5]. Even if Fil et al believe such a competing theory should be wrong, it should be cited and discussed, and would even be better to be proved wrong if their data could do it.

2) Among various experiments related to Magnus force in superconductors, two types should be particularly relevant here. One was a direct measurement of the Magnus force on moving vortices. The data indicated an agreement with the competing theory [6]. Another was to check the effective Magnus force in situations there is no change in relaxation time, but other factors are varying [7]. The data indicated a disagreement with the relaxation time controlled Magnus force theory. However, those two very relevant experiments were not cited by Fil et al.

3) One of most difficult problems has been the explanation of the Hall anomaly in superconductors: With the Magnus force as big as what expected in the classical limit, how could the Hall angle is usually not only small, but often changes its sign? One solution to this puzzle was proposed by myself in 1995 [8], to consider the vortex many-body effect, combining with the pinning effect on the scale larger than coherence length. Such idea was rediscovered by Kopnin and Vinokur in 1999 [9] (Ref.[3] in Fil et al.). However, because neither Kopnin and/or Vinokur nor Fil et al discussed those prior references, it is wrong to credit only to Kopnin and Vinokur for such an idea, when Fil et al stated According

to the current theoretical conceptions, this effect may be of macroscopic one, caused by a transverse force that may emerge at large (much larger than the core size) displacements of the vortices in the pinning potential with reference to Kopnin and Vinokur.

Incidentally, it should be mentioned that Kopnin and Vinokur [9] did credit the experimental measurement [6] of the Magnus force.

4) There are various types of vortex-phonon interactions. One was indicated in a quantitative way in 1994 [10], existing even in zero temperature limit. It has been elaborated in various experimental checkable situations [11]. It is my understanding that the major goal of Sonin [12] (Ref.[1] in Fil et al.) was to disprove the existence of such vortex-phonon effect. In the light vortex-phonon interaction method proposed by Fil et al., it does not appear appropriate to only cite Sonin.

In conclusion, without citation and discussion of those missing theories and experiments, the proper interpretation of Fil et al data will be difficult. It is not appropriate for Fil et al. to do that if they had known those works. If Fil et al were not aware of those works, the inclusion of them should enhance the value of their experimental effort.

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[13] A different discussion of the related issues can be found online:
cond-mat/0610753. http://arxiv.org/PS_cache/cond-mat/pdf/0610/0610753v1.pdf
(Two Years Later–Lessons from Vortex Dynamics in Super Media. P. Ao. 2006).